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WATER AND URBANIZATION

EDITED BY
TERJE TVEDT AND
TERJE OESTIGAARD

I.B.TAURIS

A History of Water

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Volume 1: Water and Urbanization

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Terje Tvedt *and* **Terje Oestigaard**

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Urban Water Systems—A Conceptual Framework

Terje Tvedt and Terje Oestigaard

There can be no doubt that the dominant tradition in urban studies has given scant attention to the universal and structural importance of water in urbanization processes. Peter Hall, in his acclaimed *Cities in Civilization* (1998), does discuss the role of water in the development of Rome, Paris and London, but this volume on cities in civilization has a register with no general entries on either sewage, water supply system, rivers, canals or aqueducts. In the same author's book on the future of cities from 2002, the water issue is of marginal interest (Hall, 2002). A summary of the content of all the volumes of the journal *Urban Studies* between 2006 and 2012 shows that out of 14,363 pages, only 86 pages were devoted to the water issue. These pages were not concerned with the physical or manmade environment impacting city development and affected by city development, or with its role in shaping patterns of social activities, power, or control. The few articles dealt with water as a case in studies of political–economic issues, mainly and not surprisingly the water-pricing issue. There were altogether four articles that dealt with such issues. None analyzed the interaction between water systems and cities, and how these impacted the social and economic life of the people in the cities. The book with the all-including title *Understanding the City* (Eade and Mele, 2002) does not give the water issue any attention whatsoever. A textbook in sociology in an influential series on sociology in the twenty-first century, *The World of Cities*, are only dealing with social aspects of urbanization, although it claims to be broad and comprehensive in its outlook. The book promises to "take a journey across time and space, over the urban landscape and to be historical and comparative in perspective" (Orum and Xiangming Chen, 2003: xi). It has, however, no discussion on the relationship between cities and water whatsoever, and carries not one reference to either water, rivers, sewage or waterways and canals (Orum and Xiangming Chen, 2003). Theoretical books on urban politics are neither concerned with the urban/water issue and how it frames and shapes both power relations in cities and makes footprints in the water landscape (see, for example, Parker, 2003; and Davies and Imbroscio, 2009). This volume and article takes as a starting point that modern urban studies have persistently tended to neglect the water issue and the interlinkages between city development and water. The new "cultural geography" or human geography, concerned with unmasking the meaning of cities, landscapes or buildings, unpacking it as a text, have in general not been interested in unpacking the meaning of urban water landscapes. Since one of the most important urban infrastructures, the water supply and sewage system, is a truly hidden, not visible structure in a strict material sense because they are underground and not a part of the "built landscape", this aspect of the confluence between city and water has naturally been difficult to unpack as text.

We will here show how a focus on water/urban relationships can further our knowledge of city developments, and how urban studies can deepen our understanding of the role of water in societies. The basic premises for this proposal are two facts of huge importance for understanding the history and development of the city; the universal needs of water and the actual, physical waterscape at a given place. All urban dwellers[1]—from the first few people who settled around a natural spring in a desert in Jericho and built a wall around it almost 10,000 years ago, to the Incas living in the royal city Machu Picchu on a mountain top in the Andes, to stock traders relaxing in spacious apartments in a skyscraper on Manhattan, and to the party officials assembled for one of their meetings in a grand conference hall in Beijing—share the need for one resource: water. The theoretical and empirical importance of this state of affairs can hardly be overestimated: these people all need water to survive, and as long as they live in cities, it has to be provided in one way or another. Water is the only universal urban resource that in this sense is a must and that can be controlled in this strict understanding of the word.[2]

For theoretical and empirical reasons, it is also very important for urban studies to acknowledge the natural fact that the hydraulic systems that envelop and underpin the city as climate and weather always vary, from place to place, and also from time to time at the same place. The character of the actual water system helps to define a sense of place in a fundamental way—for example, whether it is its relative humidity, the average number of rainy days, whether it receives snow and for how many months a year, or if it is situated in a desert. The urban dwellers' interactions with and their patterns of activities in relation to their water will also reflect the local hydrological cycle's particular characteristics, how their water has been modified locally in the past, and how they and their predecessors have conceived of their water and how it should be managed.

All urban places are tied up in this continuous web of relationships with water's simultaneous universalism and particularism. The geography and history of all cities in the world are therefore written in water, and in the most varied ways and manners.

There are two very different, though interrelated questions to be answered: first, how can a focus on water/urban relationships help our understanding of cities' developments; and second, how can urban studies broaden our knowledge of the role of water in societies? The possibilities of approaching these questions will be explored from a water systems perspective. The book argues that urban studies will benefit from new theoretical and conceptual approaches and a focus on water, since all cities at any time and in all places have been forced to accomodate this resource in order to grow. But how can the complex urban/water relationships be uncovered and mapped? In which manner can this broad multidimensional relationship which has impacted and changed urban history and landscapes be interpreted? How can the process and history by which city developments change and impact water landscapes be analyzed? And how can the flows of water in urban places be used to study flows of capital, power, labor, and ideas in cities?

The recognition of this range of phenomena requires some unifying approach, but an approach that can offer at the same time open and non-reductionist frameworks within which the various elements and their relationships can be analyzed.

Analyses of urban/water relationships should study the water system in its multidimensionality as an "open and multifunctional water system" (Tvedt, 2010a, 2010b). They should take into consideration the three layers of all cities' water systems: the physical, natural waterscape; the humanly modified water systems; and the ideas and managerial assumptions about water. The way "system" is used here is different from the way systems theoreticians use it. It is a descriptive term, denoting three different aspects or layers of water in connection with its social importance that are best understood in relation to each other. When the words "first", "second", and "third" layer of the water system are used, these should not be regarded as signifying a static hierarchical ordering. Instead, they denote separate, distinctive, and related, layers that also may differ in explanatory importance according to what aspect of urban development one primarily focuses on. Although specific cities in this volume are used to exemplify these layers, it is important to stress that all of these layers are present at all times, in all cities in the world—and any city could have been used to exemplify the three layers.

THE FIRST LAYER OF WATER SYSTEMS: THE NATURAL WATERSCAPE

The first layer is water's physical form and behavior. This covers precipitation and evaporation patterns, river discharges and velocity measurements, and aquifers and their behavioral characteristics (i.e., the natural waterscape or hydraulic system with relevance in the area where the city in question is located). This layer should be seen as an exogenous, physical factor, with certain particular characteristics, although these are always in a state of flux. This physical aspect of the water system should not be regarded as a separate "watery" ecosystem in nature, but as constituting a central, distinguishable aspect of all ecosystems reflecting and bringing with it traces or the meaning of the enveloping landscape. To understand how water runs through nature and urban societies, we need natural science data such as rainfall variations, rivers' sediment loads, evaporation patterns, hydrological data series, aquifer developments, etc. All of these are important, although they are of different importance to different urban places.

This focus on the physical water system and its importance for city development does not suggest a one-to-one relationship between a certain waterscape and city development. Moreover, the task of analyzing the role of the physical water context should not be seen as a simple descriptive exercise, because although water will always play a very important role in cities' location process, there is no simple causal relationship between the physical character of the water system and city locations. It is true that some places do exhibit such clear-cut causal connections, but even when there are such correlations, levels two and three of the water systems approach are equally important (see discussion below).

Everyone who has visited Jericho, the oldest urban settlement in the world, and already between 8500 and 7500 BC encircled by a defensive stone wall, knows this. In the beginning of the third millennium BC, Jericho became a flourishing city, located around the 'Ain es-Sultan. This spring, which in the Bible is known as Prophet Elisha's Spring, provided 4,000–5,000 liters of fresh water each minute. Importantly, this happened without any human action needed, and the water was easily distributed by gravity and canals. The water is still coming up from the ground, as if it is an ongoing miracle—but there are specific hydraulic reasons for it. From the earliest habitation up to the Ottoman period, this spring was the focal point for urban development and it decided the location of the city.[3] In other cases, cities are located along large rivers. Babylon, situated along the Euphrates on the Mesopotamian flood plain in today's Iraq, is often associated with the Hanging Gardens, although this has proven difficult to establish archaeologically. At the time of Nebuchadnezzar II (604–562 BC), Babylon was the leading metropolis in the world, measuring about 4.5 km^2 at the beginning of his reign. Canals from the river were built for extensive irrigation, and some of the most impressive water canals were built within the city itself. The Inner City and the Western City were both surrounded by city walls and moats. By the end of Nebuchadnezzar's reign, the eastern parts of the city were also protected by city walls and mounts, covering an area of about 9 km^2.[4] Babylon could not have developed where it did had not the Euphrates crossed the flood plain, but human modifications of the water landscape was necessary to develop and sustain it.

Rain-harvesting offers yet other possibilities. Mohenjo-Daro in present-day Pakistan was built on artificial wells and developed a sophisticated water system both for supply and sewage. It was a part of the Indus civilization and one of the largest cities in the world of the third millennium. In the city, it is estimated that there were more than 700 wells and perhaps as many as 2,000—the highest density in the world. Each of these wells had an average catchment area radius of only 17 m, making the density unparalleled in the history of water supply. The most spectacular and well-known water structure in Mohenjo-Daro is the "Great Bath", a tank 12 m × 7 m, and 2.4 m deep. However, the use and (ritual) function of this bath has been more difficult to establish. Another noteworthy development in the city is that it seems that almost every household had a separate "bathroom".[5] But the most intriguing aspect of the city is perhaps the system for sewage removal. The foundation for this water system was the fact that the water table on the Indus Plain was very close to the ground, so accessing the waters by wells was comparatively very easy.

Often a city will be dependent upon utilization of different water resources, and it is these different resources in combination that form the particular water landscape developed within a city. Aksum was the capital of the Ethiopian civilization with the rise of the kingdom of Aksum (50 BC–AD 800). The centralized state emerged in the second century AD, reaching its maximum expansion by the mid-millennium. Rainfall, surface water, and groundwater were the basis for the rural population. In the city itself, there were several springs and cisterns receiving runoff water from the surrounding hills. The largest and the most celebrated one was originally about 65 m in diameter and 5 m deep. This is seen as a rain-harvesting cistern, and together with the other wells it would have supplied a sufficient amount of water to the estimated several thousand inhabitants in the city's heyday. The name Aksum itself indicates the importance of the local water resources; it may be derived from "water"—"*ak-*" may derive from the Cushitic root for "water" and the Semitic term for "chief" is "*šum*". Another hypothesis is that the name comes from the western Agaw word "*akuəsəm*", meaning "water reservoir".[6]

Athens is a case that undermines the notion that water's impact on city location has a necessary, predictable pattern. Classical Athens was not located where it was because of an abundance of water. According to mythology, there was a competition between Athena and Poseidon regarding who could give the best gift to the city. Athena had wisdom and knowledge of arts and crafts, and Poseidon, as the god of waters, offered the Athenians a well at the Acropolis. The Athenians voted for wisdom instead of abundance of water.[7]

In the highlands of Ethiopia, one can study an example of yet another locational relationship between city and water. Here, rainfall is usually heavy but also strongly erratic and seasonal. The location of the country's capital is related to water, but not as a dire necessity. Addis Ababa has the curing and healing aspects and capacity of bathing as the point of origin. The queen of Ethiopia, Taytu Betul (*c.*1851–1918), had spent much time at thermal springs and requested her husband, King Menelik I, to build a house by a specific spring in the highlands; he complied. Soon the area developed into a royal settlement to which Taytu Betul gave the name Addis Ababa, meaning "New Flower". The king himself, aware of the curative powers of the waters, and troubled by rheumatism, established a royal enclosure, a palace, and an audience hall, paving the way for further city expansion.[8] One can still see the remnants today on a hilltop outside the center of the city.

Cities have been established not only where there is limited water availability or only one source of water, but also where there is too much water. One city with an overabundance of water is Rotterdam. Any visitor taking a boat ride around Rotterdam's river and canals will realize that this is a city where water is everywhere. The fight against too much water made this city possible, as the latter part of the name indicates. Rotterdam is a polder city (enclosed by dikes), created by man in a bid to control water. Changes in sea level and river discharges have forced the city to employ different policies throughout its history. The city has undergone several phases with regards to managing the changing water: natural water management (until 1000); defensive water management (1000–1500); anticipative water management (1500–1800); offensive water management (1800–90); manipulative water management (1890–1990); and adaptive manipulative water management (1990 until today).[9]

The physical layer of this water system approach includes not only the absence and presence of water at a given place, but also the very form and nature it takes throughout the seasons. It makes it possible to integrate in the analysis how non-cultural and non-social facts affect how water must be controlled and has to be distributed horizontally. Such non-social variables influence the technology that can be chosen, the type of equipment that must be used or can be used, the size and complexity of the water distribution system, and how it is operated, etc. Northern countries with freezing waters may be a case in point. In Finland, winter may last for up to 200 days in northern Lapland and 100 days in the southern areas. The temperature varies from −45°C to −50°C at the coldest in the north to 35°C in the summer in the south. The water infrastructure therefore needs to handle variations of at least 70°C, and because the soil freezes in the city of Tampere (in southern Finland) to a depth of about 2 m during the winter, all water and sewage pipes have to be placed at a depth of 2.5 m in order to function in extreme conditions.[10] It is obvious that a city like Tampere (subject to extreme seasonal fluctuations) will necessarily be organized and physically constructed in a different way than, for example, cities like Dhaka (flood plain) or Mecca (desert) because of differences in their respective water systems. But these natural facts are still overlooked, although they continue to produce and re-produce different possibilities and conditions for organized urban life.

Although almost all capitals and big cities are located on riverbanks (though with important exceptions), there are, as shown above, no laws or fixed pattern governing the relationship between physical water systems and city locations. A focus on water/urban relationships will, however, make possible a better understanding of how fundamental physical structures of water systems impact different cities' development. While most citizens have increasing mobility and the "flow" of people between countries and cities, and between rural areas and urban spaces, is increasing, cities remain quite fixed geographically. Indeed, one of the clear features of history is that people are stuck with the location of their cities—but at the same time they have gradually altered the original water-scape, due to improvements in technology and organizational skills.

Cities can and must change; they must be retrofitted and repurposed in relation to their water resources. Indeed, they always have been—by urban governance and citizenry; by the hydraulic engineer; and by the architect and the urban designer. Cities' relations to their water systems will become more and more challenging, because the uncertainty about future waterscapes due to global warming scenarios becomes gradually more important, and cities and their populations' expectations of and demand for water will continue to increase and diversify.

Another reason why understanding the relation between the first layer and cities' location and development should not be seen as simply a useful descriptive exercise is that the physical character of the water system is changing over time (although very slowly in some cases, reflecting the water source in question). Changing water systems will therefore impact urban location and development in various ways over time. Xi'an, which became the greatest ancient city in Chinese history with a population of up to 1 million inhabitants and an urban area covering 83.1 km^2, was surrounded by eight rivers. The name itself, Chang'an in Chinese, perhaps hints at this particular water situation, as it means "long-lasting safety and prosperity". Still, due to both the nature of the rivers and human attempts at modifying them, the city experienced water problems. Throughout the different Chinese dynasties, the city was moved to more optimal places.[11] But everyone seeing the city's surroundings today will realize that the name is still a fitting one—rivers are the arteries of the city.

THE SECOND LAYER OF WATER SYSTEMS: HUMAN MODIFICATIONS OF THE WATERSCAPE

A water system that is of relevance to a city's development will always—with specific but complex consequences—be modified in one way or another by urban action. The basic reason for this is that the physical water system underpinning a certain city's location in the first place will be "appropriated" for different demands and reasons at different points in its history. This is because the need for water will always be there and will also change over time, not only because of increases in urban population, but also because changing economic and social activities will put greater stress on the water resources. Other actors in the watershed and their efforts at using and controlling the waters must also be analyzed in order to understand the character of a particular city's water system. The human modifications will also in themselves have varying scales and histories. Most cities today are therefore enveloped by both an engineered waterscape and a waterscape that is still mirroring, to different degrees, the local character of how the hydrological cycle manifests itself in the landscape.

Specific types of modified waterscapes have been the very symbol of urbanized life, distinguishing it from the natural haphazard dominating rural life (i.e., the dependency of erratic rainfall patterns for rainfed agriculture). Fountains, in general placed at the very heart of cities, have had many functions, but one of them has been to symbolize man's control over nature—cultures' appropriation of the forces of nature. Here the unruly, treacherous water element is completely controlled, to serve human needs for aesthetic beauty.

Classical Rome was known as the city of fountains and baths, because what made the imperial capital possible was not the Pantheon or Colosseum: it was the human modifications of the waterscape. The initial localization of Rome was both mythical and practical. According to mythology, Rome was founded in *c*.753 BC by the Tiber River, "the river closest to god". The foundation myth starts with a flood, when Romulus and Remus washed ashore at the foot of the Palatine Hill. Springs, streams, and marshes were central in the early city building, and streams were channeled in order to dry saturated land. But as the city expanded, the numerous fresh water sources were insufficient to meet the city's water demands. Rome's first aqueduct, the Aqua Appia of 312 BC, ran mostly underground, and between 312 BC and AD 226, 11 aqueducts were constructed. Rome's history is one of many cases where the control of water was a main strategy for attaining power and demonstrating power.[12] A telling expression of this can still be seen: in the middle of the Four Rivers fountain by Bernini from the sixteenth century, standing in the center of Piazza Navona, there is an obelisk, and on top of that, the Pope who restored the water system in Rome had placed his personal symbol.

Byzantine Constantinople developed and was dependent upon a network of long-distance channels and reservoirs feeding the city with water. By AD 373, an estimated 130 new bridges and the first line of channels from major springs had been completed, measuring 268 km in total. Within the city, the Aqueduct of Valens had 87 arches and was 971 m long, one of the longest in the Roman world. The channel system was continuously expanded and developed, and the single length of one of the channels was 227 km. If a supplemented line from the late fourth century is included, the total length was 268 km. But this was still not enough for the city's water supply and, around AD 400, the system was extended to new springs almost 130 km from the city. When the second phase of the water supply was completed, about AD 450, the aqueduct channels had a total length of 494 km.[13]

Machu Picchu was the royal city in the Inca civilization, located in a mountaintop location. The city was established in AD 1450 and abandoned in AD 1572, but most likely ceased operation by AD 1540. Despite the importance of the city and its amazing architecture, the size and population was rather modest. Machu Picchu could support a resident population of about 300 people and up to 1,000 when the royal entourage visited the city. The annual rainfall is nearly 2,000 mm and the location of the city would not have been possible if a reliable source of groundwater had not been available. Water from the main spring was transported in a 749 m canal to the city center, which was distributed by 16 fountains still operating today.[14]

Building canals and aqueducts was not only important for cities in the past; it has also been intrinsic to many cities' development today. Los Angeles, although initially a small city with sufficient natural water resources, soon became a "desert city" because of its rapid population increase. From having around 1,500 inhabitants in 1850, the population rose to more than 100,000 in 1900, and only four years later it was 200,000. The solution to the water crisis this caused was to build an almost 360 km aqueduct from the Owens Valley in the early twentieth century, turning Los Angeles into a "hydraulic society". Yet already in the 1920s this was not enough, and the aqueduct system had to expand due to an increased population of 1.2 million in 1930, causing displacement and environmental degradation in the areas from where the water was withdrawn.[15]

One of the central issues that the water system approach aims to handle is that water is both an external, physical factor and creates one of the most interconnecting structures in cities in the form of socially appropriated, manmade water systems. In modern cities, all citizens and units—from the smallest apartments to the largest malls and factories—are physically, institutionally, and politically connected through water supply and sewage systems. In many cities, one reservoir is the main source of all the water for the entire population, and one major sewage treatment plant treats the waste water—connecting each and every person in the city through the whole process as the water is used. Thus, the physical character of water and the structures of the manmade water infrastructure are linked, and as such they create both social cohesion and social hierarchies, and these again reflect place specific forms and are continuously changing throughout history.

Dar es Salaam is one of the many cities in Africa where the well-being and health of its citizens have been hampered by incomplete and unreliable water supply and sanitation services. Today, only 10 percent have flushing toilets, while the majority is dependent upon pit latrines, which causes increased pollution, jeopardizing health conditions. Rapid urban growth, lack of investments, and unsatisfactory maintenance of the water